Institut für Volkswirtschaftslehre

Universität Augsburg

Volkswirtschaftliche Diskussionsreihe

A Neo-Darwinian Foundation of Evolutionary Economics. With an Application to the Theory of the Firm

Fritz Rahmeyer

Beitrag Nr. 309, Februar 2010

A Neo-Darwinian Foundation of Evolutionary Economics. With an Application to the Theory of the Firm.

Fritz Rahmeyer, University of Augsburg

February 2010

Abstract:

The focus of evolutionary economics is a process of continuous economic and organizational change. Currently there is no agreement on the explanation of economic evolution. Rather there are competing interpretations.

To achieve a common understanding of economic evolution, from the perspective of the history of economic thought, at first the theoretical approaches of Schumpeter and Marshall with regard to economic development or evolution are dealt with. After that, a concept of socio-economic evolution in broad agreement with evolution in nature is elaborated. It is summed up in the version of a generalized Darwinism. In this, evolution is seen as a process of change that leads to the adaptation of complex systems, the result of the causal interaction among variation, selection and retention of variety.

As a (slightly) different interpretation the presently predominating approach of neo-Schumpeterian evolutionary economics is presented. It has gained wide application to the theory of innovation and later - based on Penrose - to resource-based theories of the firm. In this the dynamic process of the creation and exploitation of resources, mainly knowledge, turns out to be the centre of attention of an evolutionary theory of the firm.

Keywords: Economic evolution, Schumpeter and Marshall, Generalized Darwinism, Evolutionary theory of the firm

JEL Classification: A12, B15, B52, D21

1. Introduction

A couple of recent survey articles concerning evolutionary economics emphasize that an agreement on the explanation of economic evolution is still missing (see i.a. Hodgson 1996, p. 699; Fagerberg 2003, p. 127; Witt 2004, pp. 125; 2008, p. 547). But there is an almost common consent in that the directed, continuous generation of economic change, resulting in the adaptation of the economic system, is the focus of interest. However, there are controversial opinions on the explanation of economic evolution (see Nelson 2006, p. 492; 2007, pp. 74). A first school of thought, first of all, derives characteristic features for structuring the economic process inductively. Following a preconception of evolutionary change, basic building blocks are the heterogeneity of individual units within a population, the constant emergence of novelty, its selection in dependency on its adaptability to the environment and the retention of attributes of the units in the passage of time. In addition, the behaviour of individual and collective agents is characterized by bounded rationality with regard to their information and competences (for that see for instance Metcalfe 2005, p. 394; Silverberg, Verspagen 2005, p. 516; Dosi, Marengo 2007, p. 492). A second school assumes that from the outset the explanation can be carried out in loose accordance with these basic principles of evolution in biology. As founding authors of an evolutionary theory of economic change (among others) Veblen, Marshall, Schumpeter, Hayek are to be named. In the narrow economic delimitation Schumpeter and Marshall are of particular importance. Within the framework of their economic analysis they deal with economic development as a relationship between stability and routine behaviour on the one hand and innovation and change on the other hand. On the central importance of innovation activities, in addition the behaviour patterns of firms as the basic unit of evolution, the currently predominant evolutionary approach of Nelson and Winter (1982) can be found. It has become indicative also for the microeconomic foundation of evolutionary economics with its main areas of application - besides the theory of economic change and innovation activity - also of the theory of the firm and Schumpeterian competition (see Nelson, Winter 2002, p. 25). Veblen is assigned to the older American Institutionalism. For him economic development consists of a succession of institutional regimes. Hayek refers to the more comprehensive sphere of cultural evolution. In accordance with that, social institutions like markets are the result of an evolutionary process of the origin of a variety of individual human actions and rule-based behaviour as well as their selection. But they are neither the outcome of a planned human design nor of natural evolution, regardless of human action. They result in a spontaneous order of the economy and the society, among others in the form of the division of labour and knowledge, in the tradition of Adam Smith.

To establish evolutionary economics from the perspective of the history of economic thought, at first the theoretical approaches of Schumpeter and Marshall concerning the content and the explanation of economic development (or evolution) are dealt with. (2.). After that, a comprehensive concept of economic evolution following evolution in nature is elaborated. It is critically summed up in the variant of a generalized Darwinism. The focus of interest of Nelson and Winter and their more applied neo-Schumpeterian version of evolutionary economics is the industry level regarded as a population of heterogeneous firms, but also their internal structure and competences (3.). Besides the studies to technical and economic change, the evolutionary research program has recently shown a close link to the resource-based theory and in extension the capability approach to the theory of the firm (Dosi, Sylos-Labini 2007, p. 337) (4.). Concluding remarks complete this essay (5.).

2. Generic Approaches to Evolutionary Economics: Schumpeter and Marshall

2.1 Schumpeter and the Process of Creative Destruction

For Schumpeter the theory of economic development is composed of the economic statics (the circular flow), the economic dynamics (economic development) as "theoretical *apparatuses"* (1934, p. 82) and the economic sociology. The latter deals with the given institutional framework of the economy and its changes that influences economic development[1] (see Schumpeter 1954a, p. 21; also Shionoya 1997, p. 7; Arena, Dangel-Hagnauer 2002, p. 3). These different areas of social life, each of them showing a development of their own, are linked with each other and lead to an indivisible social process (see Schumpeter 2006/1912, p. 1, 545; also Mathews 2007, p. 92). The circular flow as the stationary state of an economy is an abstraction, "…but only for the purpose of exhibiting the essence of what actually happens" (Schumpeter 1934, p. 9). It shows a tendency towards equilibrium as an actual force in case of a change in the economic data. Economic variables fluctuate around their normal values (ibid. 1939, p. 70). The development (or evolution) of the economy within the given institutional and historical frame of the capitalist economic system is the result of the new combination of productive factors in different forms (ibid., p. 84; also 1934, p. 66). "… (T)he different employment of the economic system's existing supplies of productive means…" (1934, p. 68) that breaks the experience and the routine activities of the stationary state (ibid., p. 80), constitutes the core of his vision of a long-term economic process (see Elliott 1983,

[1] "…economic analysis deals with the questions how people behave at any time and what the economic effects are they produce by so behaving; economic sociology deals with the question how they came to behave as they do" (Schumpeter 1954a, p. 21).

p. 278). Routine-based behaviour is nearly rational behaviour that results from a long-term adjustment and learning process. A vision always precedes the analytical research (see Schumpeter 1954a, p. 41). Schumpeter describes the theory of growth and development of the classical economists as “the theory of the organic growth of the economy” (2006/1912, p. 474). Development is the result of the growth of population and capital accumulation accompanied by a rise of demand. After an impulse by exogenous forces the growth process follows a deterministic course of adaptation.

According to Schumpeter, economic development is a consequence of technical and organizational innovations from a stream of inventions and their following diffusion. Inventions and innovations constitute different social processes. They require different personal abilities. “The inventor produces ideas, the innovator ‘gets things done’…” (ibid. 1947, p. 152; also 1934, p. 88). Innovations do not happen simultaneously by all enterprises, resulting in their differentiated growth, from that also of industries. They are carried out mainly by newly established enterprises, occur discontinuously and in swarms and transform the existing economic structure “…by its own initiative, from within” (1934, p. 63). Furthermore, they are not only the secondary cause of manufacturing activities, but rather require an agent, an entrepreneur as a man who achieves his goal in economic matters deliberately. The entrepreneur is the vehicle of innovations, he is the centre of attention in the “Theory of Economic Development.” Entrepreneurship means social leadership (1934, p. 84) but not private ownership of the means of production and the calculations of costs and returns. “The changes in the economic process brought about by innovation, together with all their effects, and the response to them by the economic system, we shall designate by the term Economic Evolution” (ibid. 1939, p. 86). The creative response to entrepreneurial activities as an internal factor of change consists in the inclusion of their results into the economic system by imitators and its adaptation to the new things created (ibid., p. 137). So evolution is regarded as a path-dependent, discontinuous process, determined by its starting point and its course (ibid. 1934, p. 64). The financing of new combinations is carried out by creation of money and bank credit through the existing banking system that detects successful entrepreneurs. Assuming full employment of productive resources, the new combination has to withdraw the required means of production from existing combinations (ibid. 1934, p. 71). In this way it gives rise to a process of creative destruction. So innovations as creative actions, entrepreneurs as agents of change, and credit accommodation to the entrepreneurs for carrying out innovations are the determining factors of economic evolution not existing in the stationary state of an economy (see Shionoya 1997, pp. 37; also Gloria-Palermo 2002, p. 25).

In a stylized way, the process of economic development or evolution consists of the emergence of variety (technical artefacts, products, production processes, behaviour patterns, organizational forms) and its selection and diffusion in the markets. It is the result of major innovations which mean a change of knowledge, and the following adjustment and coordination of resources by allocation activities of imitators as followers. These reduce the initial variety. "So the instabilities, which arise from the process of innovation, tend to right themselves, and do not go on accumulating" (Schumpeter 1928, p. 383).[2] As the result of the permanent stream of inventions and innovations, the process of economic development is undetermined and characterized also by chance.

According to the utmost significance of the entrepreneur and also the banker as his financier, to Schumpeter - following Carl Menger (Milford 1990, p. 217) - the epistemological basis of pure economic analysis is methodological individualism. It represents a reductionist way of explanation. In accordance with that, all socio-economic phenomena are traced back appropriately to individual actions alone. The whole must be explained by its given parts. The individuals are the relevant units of analysis. But this does not mean to dispute the influence of the environment on individual behaviour (see Schumpeter 1908, p. 90 f.).

Schumpeter did not elaborate a unified theoretical explanation of economic dynamics in its different phases. This is the case especially with the origin of novelties in a stationary state of the economy. But there is no deterministic reason for such an explanation (see Becker et al. 2005, p. 111). He also does not present a satisfying theory of entrepreneurial behaviour in a dynamic economy. Expressly, he refuses to make use of biological analogies in his theory (see Schumpeter 1954a, p. 789; 1934, p. 57; about that Arena, Dangel-Hagnauer 2002, pp. 11). Sanderson (1990, p. 2) points out that the first two decades of the 20th century were a "'dark' age for evolutionism", that period when Schumpeter wrote his "Theory of Economic Development." His most important contribution to economic development is the elaboration of the central meaning of internally emerging technical and organizational innovations and their diffusion accompanied by a restructuring of given productive resources in new combinations. Innovations overcome the stationary state of the economy. Starting with Metcalfe from the assumption (1998, p. 36 f.; 2005, p. 396) that the creation and directed selection of variety within a population, driven by competition and scarcity of resources, constitute the basic principles of economic development, then Schumpeter, with his theory of launching and disseminating technical and economic innovations by entrepreneurs (variational

[2] "…one could understand Being only by simultaneously understanding its Order and Motion" (Stolper 1951, p. 176).

change), their self-organisation and selection under competitive conditions and their internal development leading in turn to new varieties (transformational or developmental change), provides a broadly orientated economic contribution to a non-biological evolutionary theory of economic change.[3]

2.2 Marshall and the Process of Gradual Economic Change

Schumpeter's theory of economic development represents a deliberate alternative to the value theory of Marshall. The subject of this is the analysis of demand and supply as the fundamental idea, assuming given technological conditions and preferences, and the derivation of the normal values of economic variables in the long run. But the method of static analysis is only the starting point of economic analysis. It describes a situation of order of economic relations.[4] It is not suitable for dealing with the economic development of industries (see Marshall 1961, p. 461).

Another part of Marshall's theoretical structure is a theory of production and economic change by means of technical innovations. Characteristic features of production (ibid., pp. 314) are the existence of internal and external economies, which are the result of the division of labour in individual firms and between them and the specialization of the managerial and entrepreneurial function respectively as well as the level of industrial production, also the conception of the organic, irreversible life cycle for the growth of the firm. From an organic point of view they serve as the basis for his "Entwicklungsdenken" (evolution-mindness) (Schumpeter 1954b, p. 287) and his confidence in economic and social progress. Based on Adam Smith, economic development is produced and driven by increasing returns in production, extensions of the markets, accumulation of the firm's internal and external knowledge and management competences, in the end free competition (see Marshall 1961, p. 461). It is the core of this explanation of the dynamics of the economic process to combine standardization and routine of firms on the one hand and innovation, change and creativity on the other hand by means of the principle of continuity (see Raffaelli 2003, p. IX). The motto of the "Principles": "Natura non facit saltum" (Nature does not make a leap) is the symbol of this principle. Economic change is the result of a multitude of minor innovations on the part of a large number of small firms, but not a small number of enterprises and major innovations (see Spengler 1959, pp. 8; Lowe 1975, p. 419).

---

[3] "Nothing to do with biology per se, but everything to do with evolution" (Metcalfe 2005, p. 421).- "Schumpeter was an evolutionary thinker through and through" (Mathews 2007, p. 86).

[4] „Evolution is not possible without a substrate of order to give guidance and purpose to change" (Metcalfe 2007, p. 99).

In the preface of the “Principles” (p. XIV) Marshall’s programmatic statement can be found regarding the question whether economic and technical change shows similarity to evolution in nature: “The Mecca of economists lies in economic biology rather than in economic dynamics.” As the result of his confidence in a progressive economic and social development, it refers - following Spencer rather than Darwin - to the general rule that the shape of higher living things and the structure of social and economic activities in the process of development are characterized by a growing differentiation of their functions and at the same time a closer integration between their single parts (transformational evolution) (see Marshall 1961, p. 241). The division of labour and the origin and application of knowledge in enterprises at the same time produce a growing functional differentiation of industrial and social activities and individual competences as the further division of labour and mass production. They also lead to a closer coordination and integration of their individual parts through firms and their different organizational forms like, for example, the use of and a higher need for coordinating managerial activities (ibid., p. 241). Both consequences occur intentionally. The growth of knowledge and its use are the most important productive factors, but also the basic reasons for economic change. Knowledge is a component of capital and requires coordination and organization in enterprises (ibid., pp. 138)[5]. These are different with respect to their state of knowledge and the management capacity of the active individuals with the result of their heterogeneity (ibid., pp. 311). They realize their economic opportunities to a different degree. The managerial competences contribute to their differentiated internal development with respect to the efficiency of the production process that combines knowledge and organization.

In the course of its life cycle, the growth of a firm is limited internally by a decrease of its managerial and organizational abilities and the market entries of new competitors (”And as with the growth of trees, so it was with the growth of businesses as a general rule…”; ibid., p. 316). The diversity of firm growth is the precondition of being subject to market selection corresponding to the principles of substitution (ibid., p. 341). “The tendency to variation is a chief cause of progress…” (p. 355). Metcalfe (2007, p. 81, 100) characterizes the evolutionary process as a succession of de-coordinating forces of change through innovation activities and following coordinating adjustment processes in markets (“…the self transforming as well as the self organizing nature of capitalism.”). To summarize, according to this, evolution means a process of the internal development of firms because of the progressive division of labour and increasing returns (development

[5] „Knowledge is our most powerful engine of production; it enables us to subdue Nature and to force her to satisfy our wants. Organization aids knowledge; it has many forms,…” (Marshall 1961, p. 138).

view), but also the emergence and diffusion of technical and economic novelties and their selection in the market process (variational view) (ibid., pp. 86). So Marshall used the population method regarding both the efficiency of enterprises and their ability to innovate and grow (ibid., p. 94). Looking at both the theories of value and of production, for Marshall there exist a combination in the correspondence of the economy with mechanics (market) and biology (enterprises) (see Niman 1991, pp. 28).

Despite the frequent use of metaphors from biology in his analysis of the industrial organization of the economy, Marshall did not outline a unified theory of economic development (Clark, Juma 1988, pp. 199; Hodgson 1993, p. 406; Roncaglia 2001, p. 383). For Schumpeter (1954a, p. 836), the "Principles" as his fundamental work are "strictly static",[6] not dynamically orientated, even if for Marshall "…the central idea of economics…must be that of living force and movement" (p. XV). But Schumpeter concedes that Marshall "…understood the working of the capitalist process…He sensed the intimate organic necessities of economic life even more intensively than he formulated them…" (ibid. 1954a, p. 836). Marshall's interest in biology and evolution arises from the difficulty in integrating time into economic analysis satisfactorily, but also the realized limitation of the static analysis with respect to the theory of the firm and the value theory as a whole (see Groenewegen 2003, p. 243). Conceptions from biology are more complex than the ones from mechanics. Like Schumpeter he deals with the level of the individual firm, but also its internal development with respect to the given potential in the life cycle. From his leading ideas of change and evolution by means of a continuous interaction between innovation and the following routinization, Raffaelli (2003, p. 141) infers: "All things considered, maybe he was closer to the Mekka than he himself was able to realize."

In Schumpeter's and Marshall's view, the starting point of economic analysis is a condition of order and rest of the economy. Both authors agree that the static economic theory has to be broadened. Influenced by the 'Younger' German historical school, they are governed by the ideas of the historical development of human society and the unity of social phenomena (see Schumpeter 1954a, pp. 809; also Shionoya, Nishizawa 2008, p. 3). In their common opinion economic development or evolution is a process of the endogenously emerging self-transformation of different economic activities. It results from technical and organizational novelties, and with that set off economic adjustment processes in

[6] "This does not prevent him from dealing with evolutionary phenomena or indeed any phenomena of economic life that are refractory to the application of the methods of statics" (Schumpeter 1954a, p. 836).

markets. They are the consequences of innovation activities of entrepreneurs, but also the side effects of the production process based on the cumulatively occurring division of labour. For both of them management and entrepreneurship are important causes of economic development. Technical and economic changes go off both gradually (Marshall) and discontinuously (Schumpeter) (see Awan 1986, pp. 44; Mokyr 1990, pp. 90). They are mutually dependent. Between these extreme cases there is a continuum of technical changes. The discontinuous and the gradual approach to technical and economic change may be combined into a Schumpeter-Marshall model of economic development (see Andersen 1997, pp. 123). Both developmental patterns result in a diversity of small and large-scale firms, subject to market competition with regard to their internal growth and chance of survival.

3 Evolution in Nature and Society: Fact, Subject and Theory

3.1 Fundamentals of Biological Evolution

In general, evolution comprises a process of growth, coordination, exploitation and diffusion of new information and knowledge in different forms that results in continuous change (see Hermann-Pillath 2002, p. 22; Loasby 2002, p. 1231). Knowledge is always incomplete, available only scattered and subject to error. Its growth is the result epistemologically of conjectures and refutations, the selection of individual hypotheses (see Popper 1972, p. 261). But the growth of knowledge also consists of a history of competing research programmes which as a consequence of inertia more likely happen continuously (see Lakatos 1970, p. 155). Learning activities mainly in the surrounding of existing knowledge in a self-perpetuating process increase the knowledge base.

To elaborate a general frame of explaining the reality of evolution that also takes into consideration the peculiarities of socio-economic evolution, a concept will be worked out in loose similarity with the basic principles of Neo-Darwinism as the dominating theory of evolution in biology. In this field the evolutionary logic is composed in detail. And there are also reasons for the assumption that economic and biological evolution, in general terms, share some common features like heterogeneity of individuals, with that population thinking, the creation and selection of novelties and the retention of their forms and attributes. This attempt must rest upon observable empirical regularities of economic and social change. “Social evolution should be consistent with and not contradictory to what we know about biological evolution” (Knudsen 2002, p. 467).

Individual mechanisms of a neo-Darwinian theory of evolution[7] as a heuristic frame are the existence and at the same time the emergence of an infinite variety among the individuals of a species, their advantage or disadvantage inside the population of non-identical but similar units concerning the survival and reproduction by means of natural selection and the retention of selected individual characteristics for future generations ("A blind-variation-and-selective-retention process…"; Campbell 1960, p. 380; 1974, p. 421; comparable Hermann-Pillath 2002, pp. 206). The interactions among the Darwinian mechanisms constitute a causal explanation of adaptive change. So evolution first of all requires variety, but it both produces and destroys it. A diversity of organisms as the individuals of biological systems comes out of spontaneously occurring mutations, and more frequently a recombination of genes as the carrier of information and novelty. Both take place in an undirected way, regardless of the need of the organisms (see Mayr 1991, pp. 124). The genotype as the totality of genetic information comprises the "potential" of an organism, while the phenotype, its outside appearance, represents the "realization" of this potential (see Faber, Proops 1991, p. 63). A single entity shows a deterministic internal development. But the genotype does not react upon the phenotype, so that the genetic information is preserved unchanged. In general, concerning the distinction between genotype and phenotype as units of evolution, the one between replicator and interactor has come in useful (see Hull 1988, p. 408; Brandon 1998, pp. 177). The former transmits its characteristic features nearly consistently and repeatedly to the units of a population (unit of transmission). The latter interacts with the environment in such a way that this interrelation causes differences in the replication (process of transmission).

The natural selection of organisms with regard to the way they interact with the environment leads to a flow out of the gene pool. Those attributes of the entities that are best adapted to given environmental conditions are retained. They become the basis for further evolution. In that way continuity over time is guaranteed. The selection process results in the reproductive superiority of an organism, thereby the directed variation of the relative frequency of phenotypes inside a population (Darwin's "one long argument"). It does not go off purposefully, but opportunistically as well as coincidentally. The continual adaptation of the organisms and the stability of a population result from the competition for survival and differential growth in the face of an "overproduction" of organic variety and limitation of natural resources, but not through the initial balance of nature. Selection is effective if there exists a difference in the variety of individuals of all kind, until no further change in the structure of the population is to be expected (see

[7] For the foundation of Neo-Darwinism see Mayr 1984, pp. 454; Depew, Weber 1995, pp. 299.

Depew, Weber 1995, pp. 36; Metcalfe 1998, p. 139). It is effective as a creative power in evolution only in that case (see Gould 2002, p. 139) when the variety is limited and the accumulation of preferred subsets of a population takes place slowly and steadily, but not rapidly. Gradualism and population thinking are linked to each other. But gradualism does not imply any opinion concerning the speed of evolution (see Mayr 1994, p. 71). Evolution may run at a variable rate, depending on the stability of environmental conditions, whereas the genetic mechanism is the same in all variations. To sum up, evolution in biology is the result of a two-stage process. It comprises the emergence and the selection of genetic variety and thereby leads to a guided change within a population. The outcome is a dynamic equilibrium between adapted individuals and the environment.

For the formation of his theory of evolution, Darwin took up basic elements of English Political Economy. It was this theory of natural selection of organic variety as an external force of evolution that dominates when compared to the internal developmental driving forces of an organism, leading to its stability and balance, which he derived from Malthus' law of population as a natural force (see Schweber 1980, pp. 195; Kohn 1980, pp. 140). Using the principles of diversity and individualism to explain social and biological phenomena, he cited reasons for the advantages of increasing division of labour and the specialization in growing markets, just like those of regularity and order, which originate without intention or conscious design in the intended interactions of individual activities (see Schweber 1977, p. 280). So, for Darwin, classical Political Economy was a branch of evolutionary biology (see Schweber 1980, p. 212; Depew, Weber 1995, p. 2). Neither the invisible hand of Adam Smith nor Darwin's natural selection is directed by a rational individual or by intention. Both the neoclassical conception of the world of economics as well as the Darwinian conception of the world of biology rest on Newton's model of the balance of opposing forces.[8] They reduce complex phenomena to a sum of simple roots whose interactions determine the course of the events. Competition and selection are central forces of adjustment and balance in the economy and in biology as well, as much as the importance of gravity is to physics (see Depew, Weber 1995, p. 9).

3.2 Similarity between Nature and the Social World?

[8] „Darwin was applying the highly prized Newtonian models…bringing evolutionary theory, for the first time, into the conceptual orbit of respectable British thinking. This was done by portraying the world of nature as very like the world as political economists saw it" (Depew, Weber 1995, p. 71). – "Darwin had transformed the generalised entrepreneurial ethos of English life into a biological theory which, in turn, derived much of its support from these all-pervasive cultural commitments" (Brown 1996, p. 543).

3.2.1 Conception

To put forward an evolutionary theory of economic change following the neo-Darwinian theory of evolution in biology, both functional counterparts in the economic sphere for all evolutionary mechanisms and for entities which for the purpose of a causal explanation of change correspond to the genotype (or replicator) and phenotype (or interactor) in nature must be found. In this way this approach goes beyond the previously assumed non-Darwinian variation-selection version of evolutionary change. Reasoning by analogy, *one* form of similarity between scientific disciplines, is a method to build new hypotheses. It transfers elements of different kinds such as theories or research methods which show a similar causal meaning or characteristics among scientific disciplines (see Cohen 1993, p. 13). Metaphors, however, as a different and weaker form of similarity between natural and social science do not show any explanatory substance. But this term is also used in a different form, from time to time also as a synonym for analogy (ibid., p. 35).

The Darwinian mechanisms, however - if at all - will only represent a general frame for explaining many processes of change in the social world (see Hodgson, Knudsen 2006a, p. 15; Nelson 2006, p. 509). They will not alone be able to explain the evolutionary process of the economy in its entirety. Concerning the details, the constituting evolutionary mechanisms have to be completed through specific economic hypotheses (see Hodgson 2002, p. 270).[9] So a close structural correspondence between two disciplines and the form of the evolutionary mechanisms need not exist (see Niman 1994, p. 372; Dosi, Nelson 1994, p. 155; Nelson 2006, p. 493).

Concerning the units of selection, information, practical and scientific knowledge, individual skills and behavioural rules of the market participants for productive activities, in general, resources of different kinds, may fulfil the functional significance of genes. They are selected for application and diffusion in the form of technical artefacts, production engineering, organizational forms in firms and markets as phenotypes on a competitive basis. The selected techniques and behaviour patterns will be preserved and transmitted, through internal growth of existing and the market entries of new firms. Criterion of the selection is the adaptability of the unit, in case of the enterprise the level of production costs, the technical effectiveness, the benefits of the customers (see Nelson 2005, p. 467). Besides individual units also phenomena above the individual level like firms, organizations and institutions have a meaning of their own. They are the result of the

[9] Regarding different views concerning the meaning of Neo-Darwinism for explaining evolution in economics, see Witt 2004, pp. 127; 2008, pp. 554.

interaction between individual activities and aggregate regularities. Selection takes place on many stages as a hierarchical process. Evolutionary economics does not follow methodological individualism. Instead it is non-reductionistically orientated (see Vromen 2004, p. 233; Castellacci 2007, p. 588).

3.2.2 Critique

Now, there are important differences between evolution in nature and an evolutionary explanation of socio-economic change, mainly regarding the emergence and reduction of variety as evolutionary mechanisms. “In detail, biological and socio-economic evolution *are* very different” (Hodgson 2002, p. 272; also Hodgson, Knudsen 2006a, p. 14; Nelson 2006, p. 493). To begin with, novelties in economics and society come into being not only by chance, but also to a high degree intentionally and for a specific purpose. They are based on past experience. They are a means of individuals and firms to adapt voluntarily to their environment or even to change it, by introducing new products, production methods and/or organizational forms (see among others Ramstad 1994, pp. 83; Mc Kelvey 1996, p. 22; Cordes 2006, pp. 533; Castellacci 2007, p. 602). An evolutionary theory of economic change comprises “…’blind’ and ‘deliberate’ processes. Indeed, in human problem solving itself, both elements are involved and difficult to disentangle” (Nelson, Winter 1982, p. 11; also Vanberg 1996, p. 690). But the result also of a deliberate variation, as in the form of innovations, even if not the search for it, is characterized in all phases by uncertainty or even chance in respect to their technical and market consequences (see Cziko 1995, pp. 288; Vromen 2004, p. 233; Nelson 2006, p. 500). Internal entrepreneurial activities are accompanied by external effects of the environment, together influencing evolutionary change.

Selection of technical and economic variety is, aside from environmental pressure, also the result of foresighted human activities. It allows to change individual attributes and to take into account the long-running consequences of current decisions. The unit of selection modifies its relative frequency within its population by adapting to the environment, at the same time it develops internally as a result of selection pressure. Both forms of selection, the artificial and the natural one, have in common the retention of those individuals that are adapted to the environment and the elimination of those that cannot adapt. Selection is a universal method that takes effect in case of alternatives on the external and the internal sphere. The internal selection moderates external selection (see Geisendorf 2004, p. 89). As a result of that, novelties in the field of economics will occur less coincidentally than in the natural world.

Furthermore, in socio-economic evolution, learning, training, acquired knowledge are able to transmit information and experience over time. This way the knowledge base of individuals and enterprises will grow steadily. But new productive knowledge must be created and acquired intentionally. So the process of socio-economic evolution also takes place in accordance with the evolutionary model of Lamarck (see Nelson, Winter 1982, p. 11: Saviotti, Metcalfe 1991, p. 36; Hodgson 2001, p. 114; Knudsen 2001, p. 144). According to that variant, evolution is an exclusively vertical phenomenon: the continuous internal development of an organism or a routine, or a technical artefact in the direction of higher complexity and perfection in adaptation to environmental demand. At the same time the retention of acquired features passes to the next generation through transmission. There exists a reciprocal stream of information between the interactor and the replicator that modifies the latter. Variety is the *result* of adaptation to the external environment, for Darwin, however, it is both a *precondition* and the result of variation and selection. All in all, the evolutionary mechanisms are interdependent more than independent from one another, because human behaviour is goal-directed (see Cordes 2006, p. 538).

Against this background concerning the possible correspondence between biological and economic evolution, serious objections are raised. Witt (i.a. 1999, p. 295) comes to the following conclusion: "…in the domain of economics, there is no structure comparable in its continuity with the genetic mechanisms that have led to the emergence of species in nature." Evolution for him means a systematic, irreversible change of a system in time. It is the outcome of the self-transformations of complex systems through the origin and diffusion of novelty in different form resulting in qualitative changes of its elements (see Witt 2001, p. 49; 2004, p. 130). The three Darwinian principles do not play a part in explaining evolution. So the idea of self-transformation allows a variety of theoretical approaches outside biology. In this - compared to the neo-Darwinian approach - restricted interpretation the evolutionary economic process is characterized by means of the simultaneous effect of de-coordinating or self-reinforcing and coordinating or self-regulating forces of the market (see Witt 1985, p. 583; 1997, p. 496). Comparable to Schumpeter and Marshall, both forces of change from within resulting from new knowledge and its diffusion (differentiation) as well as of adaptation (integration) determine the economic process. Cultural, with this economic change results - following Hayek - unintentionally out of individual human actions, which at the same time generate new knowledge, but without human plan and interventions by a government. The result of the evolutionary process is not foreseeable, undetermined.

The central requirement of evolutionary economic change, also interpreted as a self-transformation process, is the emergence and diffusion of knowledge-based novelties (ibid. 1987, p. 9). They come into being endogenously by entrepreneurs who react to technical opportunities or necessary adjustments if the performance of the market is not adequate. Then, principles of explaining economic evolution are the existence and creation, selection and retention of individual variety inside a population and the development (or transformation) of single entities, both leading to a new economic structure. With this comprehensive interpretation it has to be considered that developing units, too, are subject to selection in order to find out which ones may survive in the competition of the markets (see Hodgson 2002, p. 265; Hodgson, Knudsen 2006a, p. 8). That is why there is no inconsistency between both conceptions of variation and transformation in economic evolution. They rather complement one another. But the ideas of a possible self-organisation of individual units and self-transformation of a system do not include a unified theoretical frame for explaining economic and organizational change and their adaptation to the environment compared to a broadly interpreted variation-selection approach of Neo-Darwinism.

3.2.3 Generalized Darwinism

Despite the quoted differences in the basic mechanisms of evolution, especially the role of chance and intention in case of the emergence and selection of novelties, there is, ontologically, common ground concerning the view of the structure of reality in nature and the social world, with that also in the economy. It refers to population thinking that comprises as a general framework the mechanisms of evolution by variation, selection and retention (see Aldrich et al. 2008, p. 582).[10] Therefore, the neo-Darwinian approach to evolutionary economics will be kept up in its essence. Economic evolution is both distinguished in the way that acquired characteristics are transmitted between replicator and interactor (see Fleck 2000, p. 265; Hodgson 2001. p. 114; Knudsen 2001, p. 144; Hodgson, Knudsen 2006b, p. 346; Buenstorf 2006, p. 514). In economics Darwinian evolution by way of variation of a population is accompanied by Lamarckian evolution through the transmission of acquired features over time. They do not exclude each other like in biology. The latter is also compatible with a more intentional behaviour of individuals and organisations. Through self-organisation of individuals by interaction of the units of selection leading to self-intensifying effects besides chance and selection, new structures may arise. The neo-Darwinian theory of evolution will as well explain that

[10] „..., as long as there is a population within which entities display variation in the acquisition of characteristics vital to survival, then Darwinian evolution will occur“ (Aldrich et al. 2008, p. 585).

only acquired advantageous attributes are transmitted and retained, also results of self-organizing and self-transforming processes as additional mechanisms, but the unfavourable ones are selected. It is at the same time the more detailed and comprehensive theory especially outside biology (see Dawkins 1998, pp. 20; Hodgson 2001, p. 98, 117; 2003, pp. 360). For this theoretical view the term "Universal" or recently " Generalized Darwinism" has been coined. It represents both a general, bridging principle that applies to complex population systems, as well as a monistic unlike a dualistic concept of evolution. In accordance with the latter, nature and the social world form mutually dependent spheres of reality (see Witt 2008, p. 559; Aldrich et al. 2008, p. 593).[11] This wide interpretation comes close to Nelson's demand: "…I would like to urge a broad and flexible view of evolutionary theories of change" (2006, p. 509).

3.2.4 Neo-Schumpeterian Evolutionary Economics

The subject of evolutionary economics in the currently most widely held version of Nelson and Winter - in correspondence to the previous definition - is the description and explanation of technical and economic change in enterprises and industries, especially the discovery and diffusion of technical novelties based on experience and new knowledge, and its selection on the level of enterprises. Forces of inertia retain continuity in that respect which individual and collective characteristics will survive the selection process and disseminate (see Dosi, Nelson 1994, pp. 154; Nelson 1995, p. 56). With regard to the meaning of technical and economic development both authors categorize their evolutionary approach as "Neo-Schumpeterian" (Nelson, Winter 1982, p. 39). Following the characterization of Witt (2008, p. 556), neo-Schumpeterian evolutionary economics describes a dualistic concept of evolution. According to this, biological and economic evolution constitute two separate and independent processes of reality. By emphasizing the gradual course of economic change and the management activities of firms they also find themselves in the tradition of Marshall (see Loasby 1989, p. 56; Foss 1997, p. 79; Roncaglia 2001, p. 382; Raffaelli 2003, p. 54). In contrast to Schumpeter and Marshall, besides the individual firm, they do not only look at the market level, but also at its internal organization and the role of institutions for innovation activities. The assumed difference between generalized Darwinism as a monistic and Neo-Schumpeterian evolutionary economics as a dualistic variant is hardly significant. According to

[11] „It is in the universal process of variation, differential fitness and heritability, transmission of selected variants and their combination of new variants that we have ‚universal Darwinism.' These are the processes that define a ‚Darwinian machine' " (Plotkin 1994, p. 86). – For this concept see extensively Hodgson 2002, pp. 269; 2003, pp. 368; Hodgson, Knudsen 2004, pp. 283; Aldrich et al. 2008.

Witt, it results from a different attitude concerning the structure of reality with regard to change in nature and the social world and is "..part of the researcher's informal world view…" (Witt 2008, pp. 551). They have in common - even if differently strict - the foundation following the neo-Darwinian principles. But the latter has less the intention to develop a complete model that is consistent with the framework of Neo-Darwinism. At present the neo-Schumpeterian approach predominates among the differing interpretations of evolutionary economics (ibid., p. 571). It gained broad application particularly in the theory of innovation and later the theory of the firm. For Nelson and Winter (1982, p. 18), the industry and its development are in the forefront of their analysis, which is a population of firms. It is less their intention to construct an original theory of the firm. These are characterized only in so far as they are used for the analysis of an industry. Their moulding of the firm represents an attempt to combine corresponding elements of Schumpeter and Marshall with each other. Against that the generalized Darwinism is a still unfinished research project (see Aldrich et al. 2008, p. 581). So in the following a neo-Schumpeterian interpretation of economic evolution and firm behaviour will be pursued.

4. Towards an Evolutionary Theory of the Firm

4.1 Routine-Based Theory

Nelson and Winter consider firms as goal-oriented, purposefully behaving organizations of individual activities. They are, above all, carriers of production techniques and production knowledge. The process of manufacturing (in the tradition of Marshall) is their focus of interest, but not plain exchange, contractual relations or transaction costs.[12] Unlike biological organisms, firms mainly are not passive with respect to the environment, but they interact intentionally with it. In the course of their internal development they can change their activities and attributes when adapting to the environment. Coming from behavioural theories of the firm, Nelson and Winter assume the behaviour of intended but limited rationality as well as the initial goal to meet an aspiration level (see Simon 1979, pp. 502). They refuse the assumption of optimality as a behavioural rule of firms as well as one of perfect information. Firms are seen as profit-seeking but not as profit-maximizing organizations (see Winter 1988, p. 174). Their stock of private and public knowledge, experience and competences are accumulated in the skills and habits of individuals and a hierarchy of organizational routines in production, investment,

[12] „The fact that incentives are not taken into account is a drawback shared by all the evolutionary theories of the firm" (Garrouste, Saussier 2005, p. 186).

search and innovation activities (for this differentiation see Dosi, Nelson, Winter 2000, p. 5; also Hodgson, Knudsen 2004, pp. 285). Routines that, to a high degree, are of local and specific nature constitute an almost rational, i.e consistent behaviour of firms, as already emphasized by Schumpeter (1934) with regard to the stationary circular flow of the economy.[13] They reduce the uncertainty and facilitate the coordination of their information and decision processes. They also increase the productivity of their own activities and guarantee continuity and internal stability (see Winter 1975, p. 101). Routines need not lead to optimal outcomes, but are best adapted to the prevailing environmental situation. "One conclusion from the literature review is that the term 'routine' refers to a broad range of regularities in the economy" (Becker 2004, p. 662).

For Nelson and Winter (1982, p. 14), skills and habits of individuals and routines of organisations have the same functional meaning as genes have as durable units of variation in nature, as much as firms are comparable with their phenotypes.[14] As the result of the selection both within a firm and among a population of firms, which is a hierarchical selection, the share of skills and routines which are successful and adapted to the environment will grow. Both forms of selection supplement each other and are important in a theory of economic evolution (see Aldrich, Ruef 2006, pp. 26). Intended and problem-orientated processes of learning and searching to be directed at seeking profits and that occur cumulatively and path dependent (see Teece et al. 1994, pp. 11), but also mistakes concerning the replication and the combination of routines change existing behavioural routines gradually and with delay. Those firms which show a below average level of productivity will shrink and have to adapt to the demands of the environment. Those with an above average level will gain above average profits and grow if they invest in production capacity and innovate with their own financial means (see Winter 1975, p. 105; Witt 1996, p. 712). The selection pressure against the less efficient enterprises increases. Evolutionary change shows economic processes of self-reinforcement.

The search for novelties of different kinds corresponds to the mutation and recombination of genes in the natural world (Nelson, Winter 1982, p. 128). Like selection it does not take place exclusively by chance, but also intentionally (see Nelson 2006, p. 500). So firms have a causal significance in the process of economic evolution. In contrast to optimal adaptation a variety of routines of firms as well as

---

[13] To treat rational and routine behaviour as equivalent is "…sufficiently near to reality, if things have time to hammer logic into men. Where this has happened, and within the limits in which it has happened, one may rest content with this fiction and build theories upon it" (p. 80).

[14] Nelson (2006, p. 505) stresses that in many areas of cultural evolution a firm, one sided relation between the genotype and the phenotype (or the replicator and interactor) as in biology does not exist.

skills and habits of individuals will occur, triggering evolutionary change (see Metcalfe 1995, p. 471). According to their specific routines and competences to change this kind of behaviour, firms will differ, for instance, in the level of production costs, profitability, thereby internal growth. Since they also act intentionally, both forms of economic genotypes are less stable than genetic information in the natural world. The - intended and not intended - modification of routines impedes the exact retention and transmission of knowledge and rules, thereby the explanation of stability and persistence of firm behaviour (see Becker 2004, pp. 662; Buenstorf 2006, pp. 519). This realization gives rise to a critique of a Darwinian kind of explanation of economic evolution (as before Witt 1989). In this evolutionary understanding, firms are regarded as experience- and knowledge-based organizations, capable of learning, or as “repositories of productive knowledge” (Winter 1988, p. 175). They are, as a whole, subject to external selection within their population of entities, and as a single entity they also show an irregular, internal development in order to adapt continually to alterations of the environment. As a consequence of gradual and delayed adaptation of behavioural patterns to environmental change and of bounded rationality, the evolutionary, behavioural approach is not sufficiently capable of explaining new activities like the employment of resources for innovation activities. It could not develop a long-term strategy of the firm at that time (see Winter 1987, p. 161).

4.2 Resource-Based Theories

In a later stage of development the research program of evolutionary economics extends the behavioural approach of the theory of the firm by results of management theories concerning business strategy. In accordance with that, firms are characterized by their market strategy, internal organisational structure and specific competences for the use of their given resources (see Nelson 1991, p. 67). A strategy comprises the commitments made by a firm determining its objects, based on its given resources, in a dynamic view also the search for, the selection and development of carrying out new activities and their exploitation in the production process, for instance new technologies and business plans. The structure includes the internal organization of an enterprise in order to reach its goals. Both elements decide what the core competences of an enterprise are with regard to its goals. They change only slowly as the result of bounded rationality and the given hierarchy of routines. Competences for a coordinated employment of given resources supplement the routine and learning activities. As forms of specific productive knowledge they serve as a basis for the intentional development of value creating strategies. Knowledge being stored in individuals and organisations is the most important

resource of an enterprise. It leads to the formation of competences and is also the precondition for the creation of new resources. Strategies are that part of knowledge that puts together its individual parts and allows its use it for special purposes and in certain areas (see Malerba, Orsenigo 2000, p. 297). Existing competences are the result of cumulated entrepreneurial processes of search, learning and innovations, also the transfer of knowledge that takes place path dependent, thus irreversible and directed. They establish new forms of persistent competitive advantages and strenghten the firm's ability to grow and survive (see Teece, Pisano, Shuen 1997, p. 515; Teece 2007, p. 1325).

The creation of new knowledge as an entrepreneurial resource is looked upon as the production of an immaterial, original good (see Arrow 1962, p. 614), not only embodied in capital or organizations. Knowledge is both the final product of the research department of an enterprise, as well as an intermediate product applied to increase productivity. It results from internal research and development (R&D) carried out in the organizational form of vertical integration, of cooperation with competing firms, and of the acquisition and application of external knowledge from specialized firms or organisations on secondary markets for knowledge and innovations, i.e. universities or research laboratories. But it also comes from the experience and learning of employees in manufacturing, therefore the continuous improvement of own products and production techniques (see Malerba 1992, pp. 847; Antonelli 1999, p. 247). Internally explored knowledge leads to high expenses and can afterwards either be exploited in-house or sold to competitors. It forms intentionally but without knowing its results in advance. External knowledge acquisition frequently necessitates lower costs than the creation of internal knowledge through R&D expenses. It can also be acquired by chance, unintentionally. In both cases the "common pool" of knowledge will increase as a basis for positive externalities for its further exploration and exploitation. Its creation just like the following innovations are not mainly the activities of an individual entrepreneur - as it was for Schumpeter - or a firm. They have increasingly become a collective, systemic process in which a lot of private and public participants are involved (see i.a. Pyka 2007, p. 370). So cooperation between individual units supplements selection as a mechanism of evolution. A lack of divisibility of new technical knowledge impedes its transmission among different uses or enterprises and says something for the integration of the development and conversion in new products and processes in the own enterprises (see Arora, Fosfuri, Gambardella 2001, pp. 95). Economies of scale and scope among research, development and production also contribute to this. Moreover, enterprises are able to absorb and apply external knowledge only by means of their internal research and development activities and their knowledge base. The different sources of new knowledge and

innovations are complementary to one another. Firms will probably employ them in combination (for different knowledge capacities, see U. Lichtenthaler, E. Lichtenthaler 2009, p. 1318). But there has to be a balance between the two sources of change, the exploration of new knowledge and its selection and the exploitation and retention of existing knowledge and competencies (see March 1991, p. 71). From an organizational point of view, each knowledge and innovation strategy will be combined with a special business model of a firm.

Besides market structure and firm size, determining “third” factors of creating new knowledge and innovations in-house, as technological opportunities, appropriability conditions, market demand, with that the common knowledge base, establish a stable technological paradigm or, synonymously, a technological regime (see Nelson, Winter 1977, p. 57; Dosi 1988, p. 1127). They constitute a part of the given environment for technical novelties and determine their rate and direction. The course and the result of the knowledge and innovation process will lead intentionally to internal and external learning activities for the next round of knowledge creation and have an influence on the selection and application of future techniques.

Enterprises differ from each other in the way they manage their knowledge base over time, i.e. depending on the nearness to scientific research, the transferability of knowledge, the size and growth of the market. They do not know for certain about the result of the different strategies to create and apply new knowledge. The result is a differential growth of firms, even in the same industry, and the foundations of new enterprises on the part of independent inventors, particularly in the case of major innovations, with that of changes of the market structure. Major innovations are complementary to minor ones (see Mokyr 1990, p. 297; Baumol 2002, p. 72). With bounded rationality firms prefer incremental instead of radical innovations. Correspondingly, the technical and the economic developments are characterized by periods of relative stability and of rapid change (see Basalla 1988, p. 25.).

To sum up - following Penrose (1959, p. 24) - the firm may be seen as a bundle of productive physical and human resources, capable of development. They are combined into a bundle of performances, each one different and unique, by the firm’s management, its competences. These, in turn, determine the services of the resources. Corporate growth will result in surplus firm-specific resources, for which no market exists. They make possible an expansion on production in previous and in new business activities, which on their part again lead to innovation in knowledge and resources in enterprises. Management capacities of a firm increase endogenously in the course of internal corporate growth (ibid., p. 56; 85). So firms, in the form of their provision of the resources and the supply of services, show both

qualities of heterogeneity and coherence (in the words of Marshall: differentiation and integration). As individual types of resources, tangible, physical, also intangible, for instance human capital, technical, firm-specific knowledge and organizational resources are distinguished (see Barney 1991, p. 101). In contrast to tradable productive factors, resources are not completely movable, they are difficult to imitate and substitute or none at all.

A differentiated provision with valuable scarce resources, which are not imitable, gives reason for both permanent (Ricardian) and short-term (Schumpeterian) rents, the latter out of innovations (see Peteraf 1993, p. 354; Peteraf, Barney 2003, pp. 318). Firms, at the same time, have to appropriate the resulting rents and to convert them into internal growth. Due to different competences, not all of them will realize and exploit their available opportunities for manufacturing and innovation equally. The result again is a differentiated corporate growth. Altogether, the resource-based approach of management activities and entrepreneurial function assigns a more active, intentional role to firms than merely the adaptation to a given environment or its transformation compared to the strict Darwinian interpretation of evolutionary economics. In a dynamic view, firms must discern new opportunities on the markets by means of their search routines and for that also change their organizational structure. Over and above that, the provision with given resources has to be supplemented by their capability to enlarge and modify their resource base. “A dynamic capability is the capacity of an organisation to purposefully create, extend, or modify its resource base” (Helfat et al. 2007, p. 4). Dynamic capabilities also have to be developed inside an enterprise through processes of learning and different forms of knowledge strategies and cannot be acquired on factor markets. Both resource-based approaches remain within the framework of the behavioural theory of the firm. They both will explain why firms differ persistently, either as the result of differences in the given provision with valuable resources or in capabilities for the creation and employment of new resources and their learning activities. They are, as a further element besides Schumpeterian innovation activities and bounded rationality, to a large degree compatible with the principles of evolutionary economics (see Foss 1993, p. 132). The creation and exploitation of resources, such as new knowledge, with the separate step of learning, and their subsequent growth, the in this way triggered extension of the knowledge base describes a “ knowledge evolution cycle” (Zollo, Winter 2002, p. 343) of variation, selection and retention.[15] In the course of time the new knowledge becomes more and more embedded in human behaviour (ibid., p. 344).

[15] „…, the entrepreneur function in the dynamic capabilities framework is in part Schumpeterian (the entrepreneur introduces novelty and seeks new combinations) and in part evolutionary (the entrepreneur endeavours to promote and shape learning)” (Augier, Teece 2009, p. 418).

With regard to their resources and capabilities, firms, in their heterogeneity, are in their entirety both subject to external selection within their population and show intentionally also an internal development that regenerates new variety. They gradually and with delay adapt to the environment even if not always in an optimal manner. In the economy, evolution and intentional development, variation and transformation, go along with each other (see Witt 2005, p. 340, 354; Metcalfe 2005, p. 396). The internal development results from a internal and external learning processes, also the formation of competences and capabilities. Successful behaviour will be stored in the routines of a firm. The development of a firm - contrary to the selection process - does not show regularity to a great extent. Following Penrose, the growth of a firm, caused by the company's competence and its learning and knowledge activities, is seen as a model of regularity in its internal development (critical see Witt 2005, p. 349). In general, an evolutionary theory of the firm includes the interaction between economic entities and their environment as well as among the entities inside an enterprise (see Foss 2001, pp. 332; Hodgson, Knudsen 2004, p. 301). Finally, technical and economic evolution are both the result of the unintentional, natural market selection through competitive forces of the environment, and of the intentional, voluntary entrepreneurial choices, based on the firm's resources and capabilities (see Vanberg 1996, p. 690; Spulber 2003, p. 256).

5. Concluding Remarks

There is an agreement to a large degree that the subject of evolutionary economics is a process of continuous economic change at different levels, caused by the emergence and dissemination of technical and organizational innovations and their consequences on the markets. But currently there is no common understanding regarding the explanation of evolutionary economic change. In a narrow interpretation it can be understood as a process of self-transformation of the economic system, historically with reference to Schumpeter and Marshall. In general agreement with the theoretically more comprehensive concept of Neo-Darwinian evolution in nature, it is, from an epistemological point of view, a knowledge-creating and - exploiting process of variation and selection of heterogeneous individuals and organizations. For the purpose of economic reasoning the evolutionary mechanisms need to be specified compared with their meaning in biology, but also supplemented by new evolutionary forms like cooperation between economic entities and self-organization of the units of the economic system. Within this framework, evolution in economics and the natural world is interpreted either as one sphere of reality or as two from each other differentiated fields. Correspondingly, a generalized Darwinian and a neo-Schumpeterian interpretation

of neo-Darwinian founded evolutionary economics are suggested. They represent slightly different views about communalities between biology and economics. The emphasized differences say something for a dualistic approach of economic evolution. Pragmatically, in addition the latter version has until now the decisive advantage of an extensive application to traditional economic subjects, like, above all, the innovation activity of privately owned enterprises, moreover, firm behaviour and competition in the market and for the employment and extension of productive resources. Assuming bounded rationality, internal and external learning and knowledge exploration, exploitation and retention of the firms are of utmost importance for economic change. As an alternative pattern of theoretical explanation it has to prove worthwhile in these (and other) areas in comparison with the dominant equilibrium-and optimization-oriented neoclassical theory of economics.

References:

Aldrich, H., Ruef, M. (2006), Organizations Evolving. 2nd ed. London, Thousand Oaks (Cal.), New Dehli.

Aldrich, H., Hodgson, G., Hull, D., Knudsen, Th., Mokyr, J., Vanberg, V. (2008), In defense of generalized Darwinism. Journal of Evolutionary Economics, 18, 577-596.

Andersen, E. (1997), Neo- and Post-Schumpeterian Contributions to Evolutionary Economics. In: J. Reijnders (ed.), Economics and Evolution. Cheltenham, Lyme, 109-135.

Antonelli, C. (1999), The evolution of industrial organization of the production of knowledge. Cambridge Journal of Economics, 23, 243-260.

Arena, R., Dangel-Hagnauer, C. (2002), Introduction. In: Dies. (eds.), The Contribution of Joseph Schumpeter to Economics. Routledge Studies in the History of Economics. London, New York, 1-18.

Arora, A., Fosfuri, A., Gambardella, A., (2001), Markets for Technology. The Economics of Innovation and Corporate Strategy. Cambridge (Mass.), London.

Arrow, K. (1962), Economic Welfare and the Allocation of Resources for Invention. In: R. Nelson (ed.), The Rate and Direction of Inventive Activity. NBER Special Conference Series, No. 13. Princeton, N.J., pp. 609-625.

Augier, M., Teece, D. (2009), Dynamic Capabilities and the Role of Managers in Business Strategy and Economic Performance. Organization Science, 20, 410-421.

Awan, A. (1986), Marshallian and Schumpeterian Theories of Economic Evolution: Gradualism versus Punctualism. Atlantic Economic Journal, 14, 37-49.

Barney, J. (1991), Firm resources and sustained competitive advantage. Journal of Management, 17, 99-120.

Basalla, G. (1988), The Evolution of Technology. Oxford.

Baumol, W. (2002), The Free-Market Innovation Machine. Princeton, Oxford.

Becker, M. (2004), Organizational routines: a review of the literature. Industrial and Corporate Change,. 13(4), 643-677.

Becker, M. et al. (2005), Introduction to J.A. Schumpeter, Development. The Journal of Economic Literature, 43, 108-111.

Brandon, R. (1998), The levels of selection: a hierarchy of interactors. In: D. Hull, M. Ruse (eds.), The Philosophy of Biology. Oxford, New York, 176-197.

Brown, J. (1996), Charles Darwin. Voyaging. Princeton, N.J.

Buenstorf, G. (2006), How useful is generalized Darwinism as a framework to study competition and industrial evolution? Journal of Evolutionary Economics, Vol. 16, 511-527.

Campbell, D. (1960), Blind Variation and Selective Retention in Creative Thought as in other Knowledge Processes. Psychological Review, 67, 380-400.

Campbell, D. (1974), Evolutionary Epistemology. In: P.A. Schilpp (ed.), The Philosophy of Karl Popper, Book I. La Salle (Ill.), 413-463.

Castellacci, F. (2007), Evolutionary and New Growth Theories. Are They Converging? Journal of Economic Surveys, 21, 585-627.

Clark, N., Juma, C. (1988), Evolutionary theories in economic thought. In: G. Dosi et al. (eds.), Technical Change and Economic Theory. London, New York, 197-218.

Cohen, B. (1993), Analogy, Homology, and Metaphor in the Interactions between the Natural Sciences and the Social Sciences, Especially Economics. History of Political Economy, Vol. 25, Annual Supplement: Non-Natural Social Science, ed.: N. de Marchi, 7-44.

Cordes, Ch. (2006), Darwinism in economics: from analogy to continuity. Journal of Evolutionary Economics, 16, 529-541.

Cziko, G. (1995), Without Miracles. Universal Selection Theory and the Second Darwinian Revolution. Cambridge (Mass.), London.

Dawkins, R. (1998), Universal Darwinism. In: D. Hull, M. Ruse (eds.), The Philosophy of Biology. Oxford, 15-37.

Depew, D., Weber, B. (1995), Darwinian Evolving. Cambridge (Mass.), London.

Dosi, G. (1988), Sources, Procedures, and Microeconomic Effects of Innovation. The Journal of Economic Literature, 26, 1120-1171.

Dosi, G., Nelson, R.R. (1994), An introduction to evolutionary theories in economics. Journal of Evolutionary Economics, 4, 153-172.

Dosi, G., Nelson, R.R., Winter, S. (2000), Introduction: The Nature and Dynamics of Organizational Capabilities. In: Dies. (eds.), The Nature and Dynamics of Organizational Dynamics. Oxford, New York, 1-22.

Dosi, G., Marengo, L. (2007), On the Evolutionary and Behavioural Theories of Organizations: A Tentative Roadmap. Organization Science, 18, 491-502 (2007a)

Dosi, G., Sylos-Labini, M. (2007), Technological paradigms and trajectories. In: H. Hanusch, A. Pyka (eds.), Elgar Companion on Neo-Schumpeterian Economics. Cheltenham, Northampton, MA, 331-343 (2007b). .

Elliott, J. (1983), Schumpeter and the Theory of Capitalist Economic Development. Journal of Economic Behaviour and Organization, 4, 277-308.

Faber, M., Proops, J. (1991), Evolution in Biology, Physics and Economics: A Conceptual Analysis. In: P. Saviotti, J. Metcalfe (eds.), Evolutionary Theories of Economic and Technological Change. Chur et al., 58-87.

Fagerberg, J. (2003), Schumpeter and the revival of evolutionary economics: an appraisal of the literature. Journal of Evolutionary Economics, 13, 125-159.

Fagerberg, J., Verspagen, B. (2002), Technology-gaps, innovation-diffusion and transformation: an evolutionary interpretation. Research Policy, 31, 1291-1304.

Fleck, J. (2000), Artefact↔activity: the coevolution of artefacts, knowledge and organization in technological innovation. In: J. Ziman (ed.), Technological Innovation as an Evolutionary Process. Cambridge et al., 248-266.

Foss, N. (1993), Theories of the Firm: Contractual and Competence Perspectives. Journal of Evolutionary Economics, 3, 127-144.

Foss, N. (1997), Evolutionary Economics and the Theory of the Firm: Assessments and Proposals for Research. In: J. Reijnders (ed.), Economics and Evolution. Cheltenham, Lyme, 69-107.

Foss, N. (2001), Evolutionary Theories of the Firm: Reconstruction and Relations to Contractual Theories. In: K. Dopfer (ed.), Evolutionary Economics. Program and Scope. Boston, Dordrecht, London, 319-355.

Garrouste, R., Saussier, S. (2005), Looking for a theory of the firm: Future challenge. Journal of Economic Behaviour and Organization,. 58, 178-199.

Geisendorf, S. (2004), Der ökonomische Evolutionsbegriff: Selbstorganisation und Selektion. In: M. Lehmann-Waffenschmidt, A. Ebner, D. Forndahl (Hrsg.), Institutioneller Wandel, Marktprozesse und dynamische Wirtschaftspolitik. Perspektiven der Evolutorischen Ökonomik. Marburg, 79-96.

Gloria-Palermo, S. (2002), Schumpeter and the old Austrian school: interpretations and influences. In: R.Arena, C. Dangel-Hagnauer (eds.), The Contribution of Joseph Schumpeter to Economics. London, New York, pp. 21-39.

Gould, S. (2002), The Structure of Evolutionary Theory. Cambridge (Mass.), London.

Groenewegen, P. (2003), The evolutionary economics of Alfred Marshall. In: Ders., Classics and Moderns in Economics, Vol. I. London, New York, 233-251.

Helfat, C. et al. (2007), Dynamic Capabilities. Understanding Strategic Change in Organizations. Malden, MA, Oxford, Carlton.

Hermann-Pillath, C. (2002), Grundriss der Evolutionsökonomik. München..

Hodgson, G. (1993), The Mecca of Alfred Marshall. The Economic Journal, 103, 406-415.

Hodgson, G. (1996), The Challenge of Evolutionary Economics. Journal of Institutional and Theoretical Economics, 152, 697-706.

Hodgson, G. (2001), Is Social Evolution Lamarckian or Darwinian? In: J. Laurent, J. Nightingale (eds.), Darwinism and Evolutionary Economics. Cheltenham, Northampton (Mass.), 87-120.

Hodgson, G. (2002), Darwinism in economics: from analogy to ontology. Journal of Evolutionary Economics, 12, 259-281.

Hodgson, G. (2003), The Mystery of the Routine. Revue Economic, 54, 355-384.

Hodgson, G., Knudsen, T. (2004), The firm as an interactor: firms as vehicles for habits and routines. Journal of Evolutionary Economics, 14, 281-307.

Hodgson, G., Knudsen T. (2006), Why we need a generalized Darwinism, and why generalized Darwinism is not enough. Journal of Economic Behaviour and Organization, 61, 1-19 (2006a)

Hodgson, G., Knudsen, T. (2006), Dismantling Lamarckism: why descriptions of socio-economic evolution as Lamarckian are misleading. Journal of Evolutionary Economics, 16, 343-366 (2006b).

Hull, D. (1988), Science as a Process. Chicago, London.

Knudsen, T. (2001), Nesting Lamarckism with Darwinian Explanations: Necessity in Economics and Possibility in Biology? In: J. Laurent, J. Nightingale (eds.), Darwinism and Evolutionary Economics. Cheltenham, Northampton (Mass.), 121-159.

Knudsen, T. (2002), Economic selection theory. Journal of Evolutionary Economics, 12, 443-470.

Kohn, D. (1980), Theories to work with: Rejected Theories, Reproduction, and Darwin's Path to Natural Selection. Studies in the History of Biology, 4, 67-170.

Lakatos, I. (1970), Falsification and the Methodology of Scientific Research Programmes. In: I. Lakatos, A. Musgrave (eds.), Criticism and the Growth of Knowledge. London, New York, pp. 91-195.

Lichtenthaler, U., Lichtenthaler, E. (2009), A Capability-Based Framework for Open Innovation: Complementing Absorptive Capacity. Journal of Management Studies, Vol. 46, pp. 1315-1338.

Loasby, B. (1989), Knowledge and Organization: Marshall's theory of economic progress and coordination. In: Ders., The Mind and Method of the Economist. Aldershot, 47-70.

Loasby, B. (2002), The evolution of knowledge: beyond the biological model. Research Policy, Vol. 31, pp. 1227-1239.

Lowe, A. (1975), Adam Smith's System of Equilibrium Growth. In: A. Skinner, Th. Wilson (eds.), Essays on Adam Smith. Oxford, 415-425.

Malerba, F. (1992), Learning by Firms and Incremental Technical Change. The Economic Journal, 102, 845-859.

Malerba, F., Orsenigo, L. (2000), Knowledge, Innovation Activities and Industrial Evolution. Industrial and Corporate Change, 9, 289-314.

March, J. (1991), Exploration and Exploitation in Organizational Learning. Organization Science, 2, S. 71-87.

Marshall, A. (1961), Principles of Economics, 9th (variorum) ed., Vol. 1. Text. London et al.

Mathews, J.A. (2007), Reflections on Schumpeter's ‚lost' seventh chapter to the *Theory of Economic Development* In: H. Hanusch, A. Pyka (eds.), Elgar Companion to Neo-Schumpeterian Economics. Cheltenham, Northampton, MA, 78-96.

Mayr, E. (1984), Die Entwicklung der biologischen Gedankenwelt. Berlin u.a.

Mayr, E. (1991), Eine neue Philosophie der Biologie. München, Zürich.

Mayr, E. (1994), …und Darwin hat doch recht. Charles Darwin, seine Lehre und die moderne Evolutionstheorie. München, Zürich.

Mc Kelvey, M. (1996), Evolutionary Innovations. The Business of Biotechnology. Oxford et al.

Metcalfe, J. (1995), The Economic Foundations of Technology Policy: Equilibrium and Evolutionary Perspectives. In: P. Stoneman (ed.), Handbook of the Economics of Innovation and Technical Change. Oxford, Cambridge (Mass.), 409-512.

Metcalfe, J. (1998), Evolutionary Economics and Creative Destruction. London, New York.

Metcalfe, J. (2005), Evolutionary concepts in relation to evolutionary economics. In: K. Dopfer (ed.), The Evolutionary Foundations of Economics. Cambridge et al., 391-430.

Metcalfe, J. (2007), Alfred Marshall and the General Theory of Evolutionary Economics. History of Economic Ideas, 15, No. 1, 81-110.

Milford, K. (1990), Menger's methodology. History of Political Economy, Vol. 22. Annual Supplement (ed. B. Caldwell), Carl Menger and his legacy in economics, 215-239.

Mokyr, J. (1990), The Lever of Riches. Technological Creativity and Economic Progress. New York, Oxford.

Nelson, R.R. (1991), Why Do Firms Differ, And How Does It Matter? Strategic Management Journal (Special Issue Winter), 12, 61-74.

Nelson, R.R. (1995), Recent Evolutionary Theorizing about Economic Change. The Journal of Economic Literature, 33, 48-90.

Nelson, R.R. (2005), Perspectives on technological evolution. In: K. Dopfer (ed.), The Evolutionary Foundations of Economics. Cambridge et al., 461-471.

Nelson, R.R. (2006), Evolutionary social science and universal Darwinism. Journal of Evolutionary Economics, 16, 491-510.

Nelson, R.R. (2007), Universal Darwinism and evolutionary social science. Biology and Philosophy, 22, 73-94.

Nelson, R.R., Winter, S. (1977), In Search of Useful Theory of Innovation. Research Policy, 6, 36-76.

Nelson, R.R., Winter, S. (1982), An Evolutionary Theory of Economic Change. Cambridge (Mass.).

Nelson, R.R., Winter, S.G. (2002), Evolutionary Theorizing in Economics. The Journal of Economic Perspectives, 15, No. 2, 23-46.

Niman, N. (1991), Biological Analogies in Marshall's Work. Journal of the History of Economic Thought, 13, 19-36.

Niman, N. (1994), The role of biological analogies in the theory of the firm. In: Ph. Mirowski (ed.), Natural images in economic thought. Cambridge (UK), New York, Melbourne, 360-383.

Penrose, (1959), The Theory of the Growth of the Firm. Oxford.

Peteraf, M. (1993), The cornerstones of competitive advantage: a resource-based view. Strategic Management Journal, Vol. 14, 179-191.

Peteraf, M., Barney, J. (2003), Unraveling the Resource-Based Tangle. Managerial and Decision Economics, 24, 309-323.

Plotkin, H. (1994), Darwin Machines and the Nature of Knowledge. Harmondsworth.

Popper, K. (1972), Evolution and the Tree of Knowledge. In: Ders., Objective Knowledge. An Evolutionary Approach. Oxford, S. 246-284.

Pyka, A. (2007), Innovative networks. In: H. Hanusch, A. Pyka (eds.), Elgat Companion of Neo-Schumpeterian Economics. Cheltenham, Northampton, MA, 360-376.

Raffaelli, T. (2003), Marshall's Evolutionary Economics. London, New York.

Ramstad, Y. (1994), On the Nature of Economic Evolution: J.R. Commons and the Metaphor of Artificial Selection. In: L. Magnusson (ed.), Evolutionary and neo-Schumpeterian Approaches to Economics. Boston, Dordrecht, London, 65-121.

Roncaglia, A. (2001), The Wealth of Ideas. A History of Economic Thought. Cambridge et al.

Sanderson, S. (1990), Social Evolutionism. A Critical History. Cambridge (Mass.), Oxford.

Saviotti, P., Metcalfe, J. (1991), Present development and Trends in Evolutionary Economics. In: Dies. (ed.), Evolutionary Theories of Economic and Technological Change. Chur et al., 1-30.

Schumpeter, J. (1908), Das Wesen und der Hauptinhalt der theoretischen Nationalökonomie. München, Leipzig.

Schumpeter, J. (1928), The instability of capitalism. The Economic Journal, Vol. 38, 361-386.

Schumpeter, J. (1934), The Theory of Economic Development. New York 1961.

Schumpeter, J. (1939), Business Cycles. New York, London.

Schumpeter, J. (1947), The creative response in economic history. Journal of Economic History, 7, 149-159.

Schumpeter, J. (1954), History of Economic Analysis. London (1954a).

Schumpeter, J. (1954), Alfred Marshall 1942-1924. In: Ders., Dogmenhistorische und biographische Aufsätze. Tübingen, 285-303 (1954b).

Schumpeter, J. (2006/1912), Theorie der wirtschaftlichen Entwicklung. Nachdruck der 1. Auflage, Berlin 1912.

Schweber, S. (1977), The Origin of the Origin revisited. Journal of History of Biology, 10, 229-316.

Schweber, S (1980), Darwin and the Political Economist: Divergence of Character. Journal of History of Biology, 13, 195-289.

Shionoya, Y. (1997), Schumpeter and the idea of social science. Cambridge.

Shionoya, Y., Nishizawa, T. (2008), Introduction. In: Y. Shionoya, T. Nishizawa (eds.), Marshall and Schumpeter on Evolution. Cheltenham, Northampton, MA, pp. 1-12.

Silverberg, G., Verspagen, B. (2005), Evolutionary theorizing on economic growth. In: K. Dopfer (ed.), The Evolutionary Foundations of Economics. Cambridge et al., 506-539.

Simon, H. (1979), Rational Decision Making in Business Organization. The American Economic Review, 69, 493-513.

Spengler, J. (1959), Adam Smith's Theory of Economic Growth-Part II. The Southern Economic Journal, 26, 1-12.

Spulber, D. (2003), The Intermediation Theory of the Firm: Integrating Economic and Management Approaches to Strategy. Managerial and Decision Economics, 24, 253-266.

Stolper, W. (1951), Reflections on Schumpeter's Writings. The Review of Economics and Statistics, 33, 170-177.

Teece, D. et al. (1994), Understanding Corporate Coherence. Theory and Evidence. Journal of Economic Behaviour and Organization, 23, 1-30.

Teece, D. (2007), Explicating Dynamic Capabilities: The Nature and Microfoundations of (Sustainable) Enterprise Performance. Strategic Management Journal, 28, 1319-1350.

Teece, D., Pisano, G., Shuen, A. (1997), Dynamic Capabilities and Strategic Management. Strategic Management Journal, 18, 509-533.

Vanberg, V. (1996), Institutional Evolution with Constraints. Journal of Institutional and Theoretical Economics, 152, 690-696.

Vromen, J. (2004), Conjectural revisionary economic ontology: Outline of an ambitious research agenda for evolutionary economics. Journal of Economic Methodology, 11, 213-247.

Winter, S. G. (1975), Optimization and evolution in the theory of the firm. In: R. Day, T. Groves (eds.), Adaptive Economic Models. New York, 73-118.

Winter, S.G. (1987), Knowledge and Competence as Strategic Assets. In: D. Teece (ed.), The Competitive Challenge. New York, 159-184.

Winter, S.G. (1988), On Coase, Competence and Corporation. Journal of Law, Economics, and Organization, 4, 163-180.

Witt, U. (1985), Coordination of Individual Economic Activities as an Evolving Process of Self-Organization. Economie Appliquee, 37, 569-595.

Witt, U. (1987), Individualistische Grundlagen der evolutorischen Ökonomik. Tübingen.

Witt, U. (1996), A “Darwinian Revolution” in Economics? Journal of Institutional and Theoretical Economics, 152, 707-716.

Witt, U. (1997), Self-Organization and economics- what is new? Structural Change and Economic Dynamics, 489-507.

Witt, U. (1999), Evolutionary Economics and Evolutionary Biology. In: P. Koslowski (Hrsg.), Sociobiology and Bioeconomics. Berlin, Heidelberg,, 279-298.

Witt, U. (2001), Evolutionary Economics: An Interpretative Survey. In: K. Dopfer (ed.), Evolutionary Economics. Program and Scope. Boston, Dordrecht, London, 45-88.

Witt, U. (2004), On the proper interpretation of ‘evolution’ in economics and its implications for production theory. Journal of Economic Methodology, 11(4), 125-146.

Witt, U. (2005), The evolutionary perspective on organizational change and the theory of the firm. In: K. Dopfer (ed.), The Evolutionary Foundations of Economics. Cambridge, 339-364.

Witt, U. (2008), What is specific about evolutionary economics? Journal of Evolutionary Economics, 18, 547-575.

Zollo, M., Winter, S. (2002), Deliberate Learning and the Evolution of Dynamic Capabilities. Organization Science, Vol. 13, pp. 339-351.